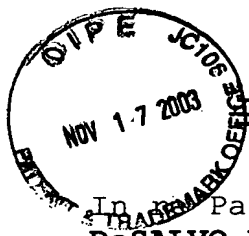


#14 Declaration  
3mw/12-5-03



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Patent Application of:  
**DeSALVO ET AL.**

Serial No. **09/724,256**

Filing Date: **November 28, 2000**

Confirmation No. **7913**

For: **OPTICALLY AMPLIFIED  
RECEIVER**

)  
)  
) Examiner: H. Phan

)  
)  
) Art Unit: 2633

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NOV 19 2003

Technology Center 2600

**DECLARATION UNDER 37 C.F.R. 1.131**

Mail Stop Non-Fee Amendment  
Commissioner for Patents  
P. O. Box 1450  
Alexandria, VA 22313-1450

Sir:

We, **JOHN DeSALVO, MICHAEL LANGE, SCOTT BRICKER,  
RANDALL K. MORSE and JANE CLAIRE WHITE**, hereby declare:

1. We are the joint inventors of claims 1-31 of U.S. patent application serial no. 09/724,256 identified above, and the subject matter described and claimed therein.

2. Prior to September 30, 1998, the effective date of cited U.S. Patent No. 6,384,948 to Williams et al., we had conceived our invention that is described and claimed in the above-identified patent application while working in the United States in the Palm Bay, Florida facility of Harris Corporation. We worked diligently on developing the claimed invention from the time of conception to reduction to practice at a date before September 30, 1998. From the time of reduction to practice to the filing of the above-identified

In re Patent Application of:

**DeSALVO ET AL.**

Serial No. 09/724,256

Filing Date: 11/28/2000

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patent application, we worked diligently on developing a commercially feasible optically amplified receiver of the present invention.

3. Before September 30, 1998, joint inventors, Randall K. Morse and Jane Claire White, had initially worked on the development of a structure and circuit for optically amplifying signals to deliver a clean current source through an injection laser diode as part of an optically amplified receiver that optimizes a system and is incorporated into a single assembly. Joint inventors, Morse and White, were later joined by joint inventors, DeSalvo, Lange and Bricker, before September 30, 1998 to design an improved optically amplified receiver based upon the initial research of joint inventors, Morse and White.

4. Before September 30, 1998, we conceived an optically amplified receiver using an optical preamplifier, bandpass filter, PIN detector and amplifier circuit. Initial conception drawings are shown in the laboratory notebook sheets 1 and 2 of Exhibit 1 attached hereto. Pages 3-7 of this exhibit also show the development and the initial conception of the optically amplified receiver. As evident, it includes an optical preamplifier for receiving an optical communications signal over a fiber optic communications line. The bandpass filter receives the signal and selects the signal channel and filters out noise. A PIN detector receives the optical communications signal from the bandpass filter and converts the optical communications signal into an electrical communications signal. An amplifier circuit amplifies the electrical communications signal. Sheet 7 shows a technical memorandum that was written by one of the joint inventors.

In re Patent Application of:

**DeSALVO ET AL.**

Serial No. **09/724,256**

Filing Date: **11/28/2000**

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5. The joint inventors worked diligently to reduce to practice this invention and tested the invention as shown by the receiver sensitivity experiment on sheet 8 of the laboratory notebook in Exhibit 1 before the September 30, 1998 effective date of the Williams et al. reference.

6. The dates are deleted on the sheets from Exhibit 1 and all dates are prior to September 30, 1998.

7. We hereby declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.


11/7/2003  
Date


11/6/03  
Date

11/6/03  
Date

11-6-03  
Date

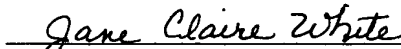
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JOHN DeSALVO

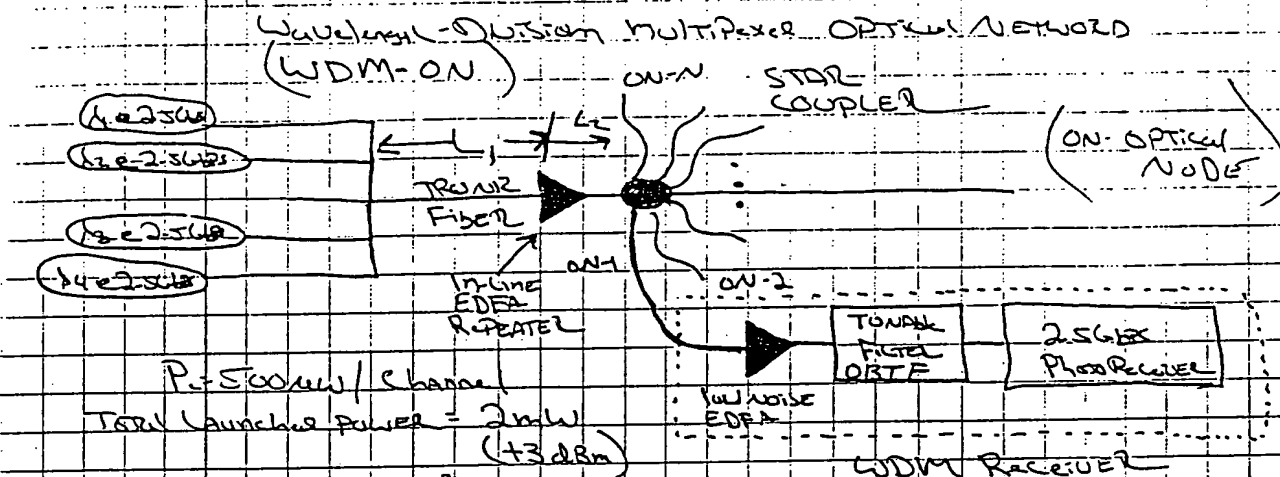
  
MICHAEL LANGE

  
SCOTT BRICKER

 11-6-03  
RANDALL K. MORSE

  
JANE CLAIRE WHITE

## LOW-NOISE WDM RECEIVER



$P_i = 500 \text{ mW / Channel}$   
Total launched power =  $2 \text{ mW}$   
(+3 dBm)

L1 - Fixed SPIN to first

REPEATER EDFA (ASSUME  
L<sub>2</sub> - Fiber length between STAR coupler  
and EDFA Repeater (244.1))

## WDM Receiver

$$\alpha_L = (0.2 \text{ dB/km})(50)$$

$$(\alpha_L = 10 \text{ dB})$$

1264	STAR COUPLER - 18 dB LOSS
------	---------------------------

Fixed

-18 dB

1 ex - 2 dB

Excess optical loss per span  $\times 2 = 4 \text{ dB}$

5.4x	-0.5dB
------	--------

excess STAR coupled insertion loss -0.5

L <sub>bp</sub>					-2.0 dB
-----------------	--	--	--	--	---------

UBTF Insertion loss	-2.0
---------------------	------

$$-24.5$$

The WDM RECEIVER IS CAPABLE OF ACCEPTING MULTIPLE OPTICAL CHANNELS ON A SINGLE FIBER, AMPLIFYING THEM ONE EACH CHANNEL AS SHOWN ABOVE, OR DEMULTIPLEXING THEM INTO INDIVIDUAL CHANNELS FOR SIMULTANEOUS RECOVERY. THE OPTICAL AMPLIFIER IS USED TO PROVIDE HIGH SENSITIVITY, PROBABLY BETTER THAN AN APD.

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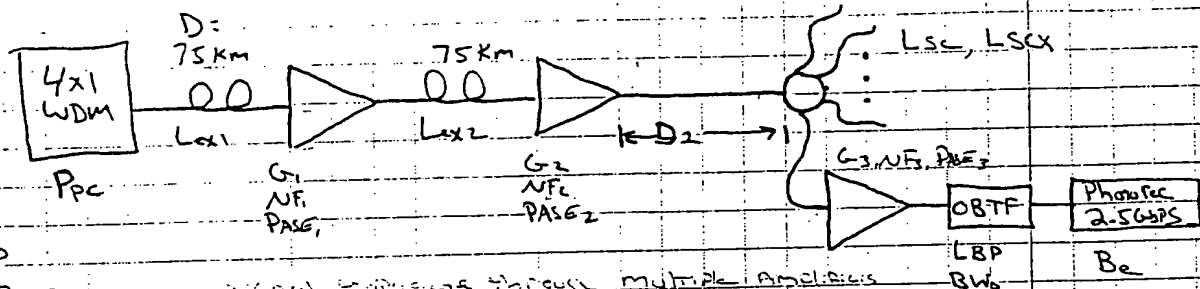
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Dean

1

# Point-to-Point WDM Line Analyzer



$P_{pc}$  - AUG. 40

OPTICAL POWER

Power WDM cou.

$L_x$  - EXCESS LOSS

PER SPAN

$D$  - FIBER SPAN

between

REPEATERS

$D_2 \leq D/2$  (Routing Parameter)

$$L_1 = e^{-\alpha D}$$

$$L_2 = e^{-\alpha D_2}$$

$$\alpha = 0.2 \text{ dB/km}$$

FIBER ATTENUATION LOSS

$$L_{sc} = -10 \log_{10} [N_u], N_u = \# \text{ OF USERS FOR STAR COUPLER}$$

$L_{sx}$  - EXCESS LOSS IN STAR COUPLER

- In-line amplifiers compensate only for fiber attenuation loss  $\Rightarrow G = e^{\alpha D}$ . Therefore, the signal power out of the EDFA is equal to its value at the beginning of the span.

- Routing loss is defined as the total loss to the signal that occurs immediately following the last in-line EDFA in addition to the excess losses occurring in the trunk lines that are not compensated by the in-line EDFA gain.

$$L_R = L_{ex} + e^{-\alpha D_2} + L_{sc} + L_{sx}$$

- There is one last loss element between the EDFA preamplifier and the photoreceiver, the tunable optical bandpass filter, LBP.

$$C = .5(1 - 10^{-\frac{\alpha L}{10}})$$

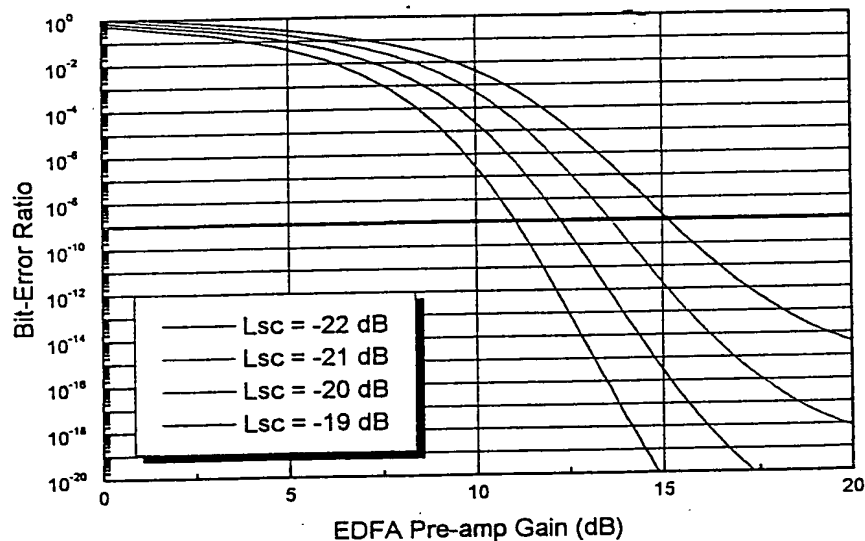
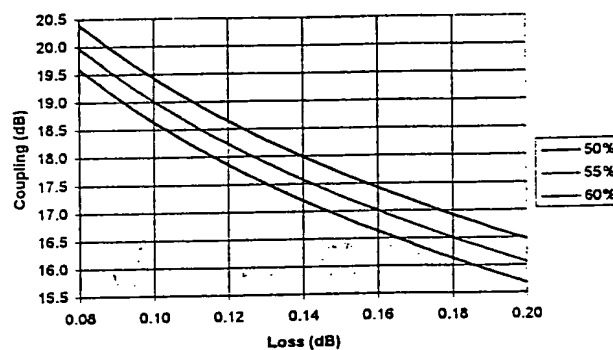
$$-19.4 \text{ dB}$$

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Loss (dB)	Coupling @ CE=50%	Coupling @ CE=55%	Coupling @ CE=60%
0.080	20.4	20.0	19.6
0.085	20.1	19.7	19.3
0.090	19.9	19.5	19.1
0.095	19.7	19.2	18.9
0.100	19.4	19.0	18.6
0.105	19.2	18.8	18.4
0.110	19.0	18.6	18.2
0.115	18.8	18.4	18.0
0.120	18.7	18.2	17.9
0.125	18.5	18.1	17.7
0.130	18.3	17.9	17.5
0.135	18.2	17.7	17.4
0.140	18.0	17.6	17.2
0.145	17.8	17.4	17.1
0.150	17.7	17.3	16.9
0.155	17.6	17.1	16.8
0.160	17.4	17.0	16.6
0.165	17.3	16.9	16.5
0.170	17.2	16.8	16.4
0.175	17.0	16.6	16.3
0.180	16.9	16.5	16.1
0.185	16.8	16.4	16.0
0.190	16.7	16.3	15.9
0.195	16.6	16.2	15.8
0.200	16.5	16.1	15.7



The condition / Assumption

Used in the analysis are:

- $L_{ex} = 0$ , the in-line amplifier compensates for any small loss that occur in a span.

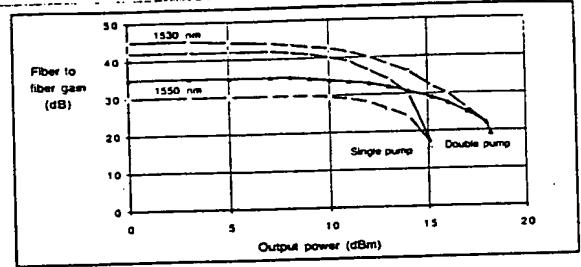
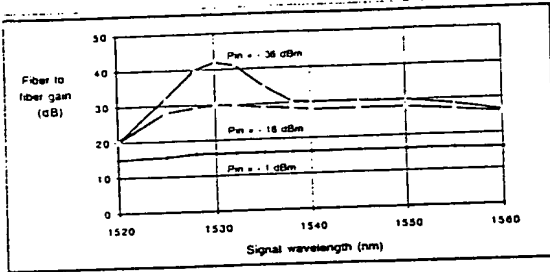
- $L_1 = -18.75 \text{ dB} \Rightarrow$  the in-line EDFA must provide at least 18.75 dB of gain.

Per WDM channel. The noise figure of the in-line EDFA was fixed at 5.5 dB.

- $D_2$ , the maximum distance the star coupler can be placed from an in-line EDFA is  $D_1/2$ , therefore, the signal level (i.e. the launched power per channel) will drop by 9.4 dB (no more than).

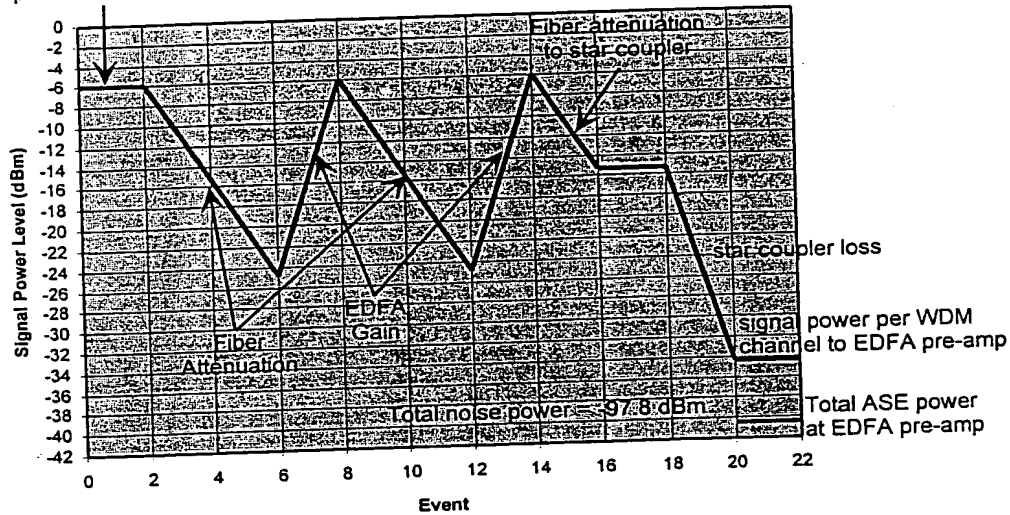
- WDM signal is distributed to the optical nodes using a 64 channel star coupler with loss,  $L_{sc} = -18 \text{ dB}$ . Excess losses (coupler efficiency) are to be assumed in the 1 to 3 dB range.

- A representation of the system power budget showing the signal power level per WDM channel at the EDFA pre-amp input is shown on the next page.

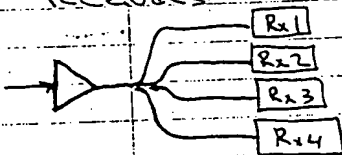


### Optical Representation of WDM System Power Budget

Launched signal power per WDM channel



To Simultaneously Recover the 4 WDM Signals, the optical signal out of the EDFA pre-amp must be split 4-ways to individual receivers

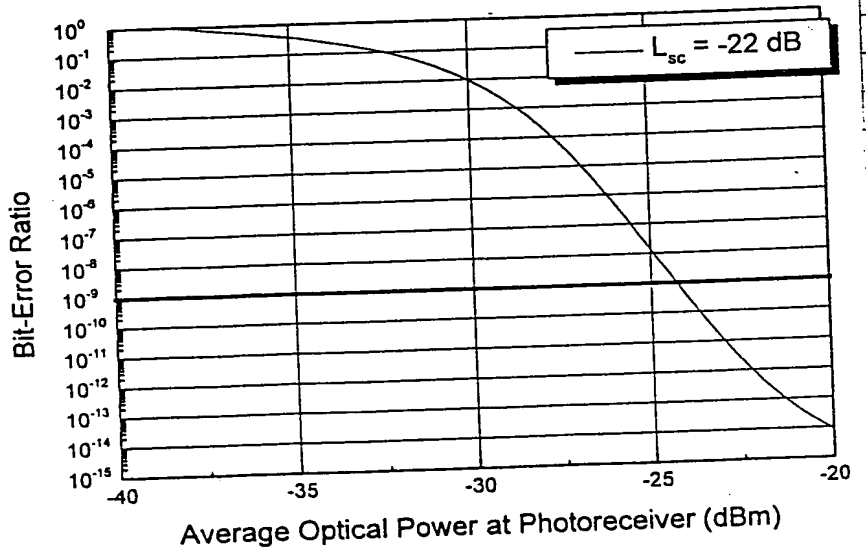


We'll use the worst-case coupling loss of -22 dB for this analysis

Trading

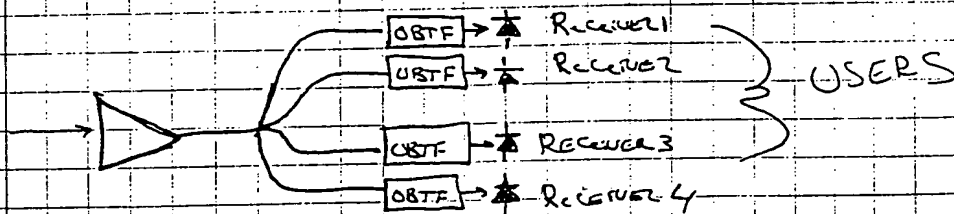
the de-multiplexing losses,

EDFA pre-amp gain, and the addition of another EDFA used to compensate for the additional splitting losses if the pre-amp gain alone is not adequate

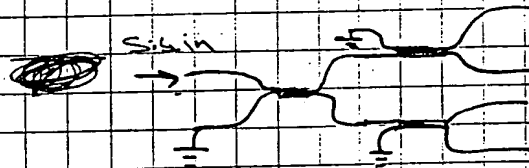


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# POWER SPLITTER / OPTICAL BANDPASS TUNABLE FILTER DE-MULTIPLEXER



POWER SPLITTER: CASCADED 3-dB COUPLERS



Minimum  
Insertion Loss = -6 dB  
Typical IL = -7 dB

OBTF Characteristics are the same as in its analysis, i.e. approx 2 dB insertion loss over tunability over the input signal wavelength range. Assumed loss is independent of center wavelength.

## ADVANTAGES

- VARIABLE Signal Wavelength
  - Reconfigurable Network
  - Add/Drop Multiplexing
- User ~~choose~~ <sup>selectable</sup> Signal band
  - WDM distribution Network

## Disadvantages

- LOSSY

For 20 dB Pre-amp gain, including a Power Splitter (-7 dB) insertion loss would result in a ~~Power~~ BER =  $3 \times 10^{-6}$

To achieve a minimum BER =  $10^{-9}$ , the EDFA pre-amp gain would only need to be increased to G = 22.2 dB

SEE PLOT ON  
Following PAGE



# Tunable Fabry-Perot Etalon Filter

JDS F.T. 1

TB250UM

Wavelength	FSR	RW	F	IL
1520-1570	50-85	.4-.9	100	<2.5

TB250-CB

Tracking Filter

"		.2-1.0	40-100	<5
---	--	--------	--------	----

TB250-EL

Controller

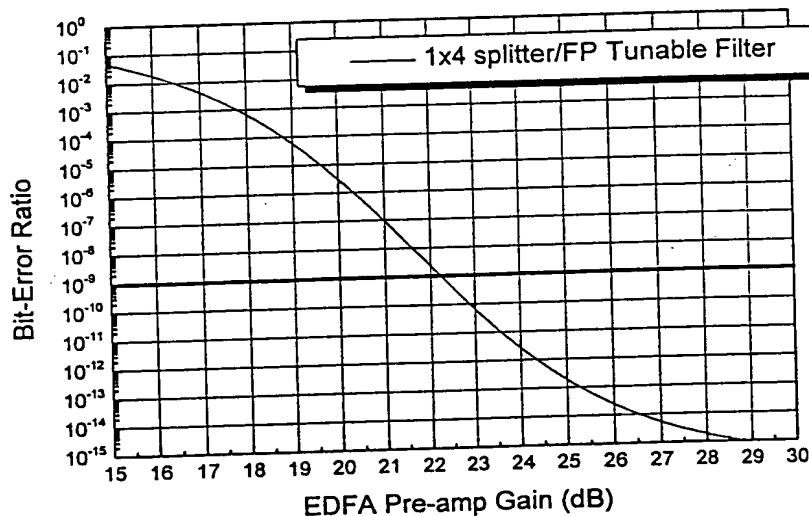
Unit

MICRON OPTICS

In-line Fiber FP Filters

Loss <2 dB

SANTER



## Electrical Power Dissipation Issue

- Phoned Olivier Guy @ Photonics (617) 245 2333
- Gave him Lucant's Spec. Notes for a comparable Amplifier
- Will Fax France to ask about Reducing the dissipated electrical power

See Page 88 Regarding Fax-back from France

Technical Memorandum  
JA 4139-0301

Title: Sensitivity Calculation for an  
EDFA Pre-Amplified pin Photodetector  
Receiver

Author: Richard DeSalvo

1.0 Introduction

This memo summarizes the analysis performed in calculating the receiver sensitivity for an erbium-doped fiber optical pre-amplifier and pin photodetector. The receiver is assumed to operate at 2.488 Gb/s. The EDFA is modeled after the OptiGain Model 4012 optical pre-amplifier and the receiver module is modeled after the Sumitomo SDT 8908-R-Q fiber optic receiver module. The analysis is based on Chapter 3, "Photodetection of optically amplified signals," in Desurvire's Erbium-Doped Fiber Amplifiers - Principles and Application. A block diagram describing the components modeled and their appropriate parameters is shown in Figure 1.

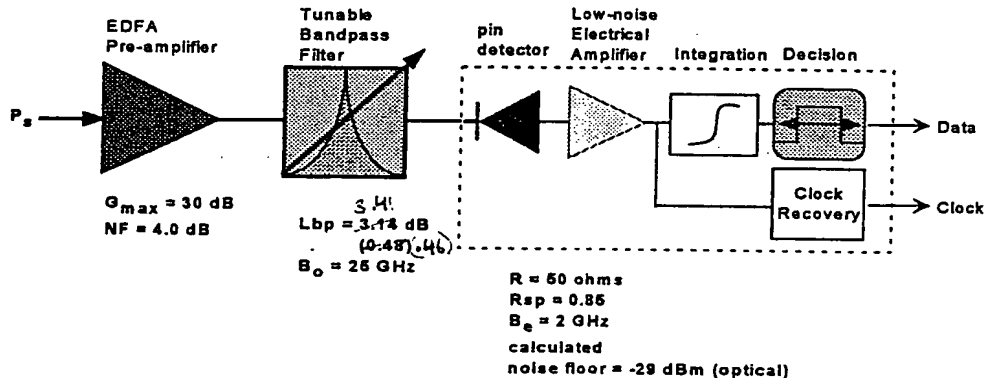


Figure 1 Block diagram representation of an OPA + D receiver with parameters used in the sensitivity model presented.

Receiv  
to  
ADAPTIVE

# RECEIVER SENSITIVITY EXPERIMENT

Photonic EDFA

$$\text{Calculated } \bar{P} = -40.8 \text{ dBm}$$

$$\text{Theoretical } \bar{P} = -47.1 \text{ dBm}$$

$$G_{\text{oss}} = 27 \text{ dB}, NF = 4.5 \text{ dB}$$

OPCavity loss ~~5.82~~

$$\text{OTF BW} = 2.5 \text{ GHz}$$

$$IL = 4.92 \text{ dB}$$

$$B_n = 2 \text{ GHz} \quad NP = -29 \text{ dBm}$$

$$K_{01} = 13 \text{ dB}$$

$$\text{MEASURED } \bar{P} = -39.7 \text{ dBm}$$

Using OPTIGAIN EDFA, we measure a  
Receiver Sensitivity =  $\bar{P} = -41.5 \text{ dBm}$

$$-41.5 \text{ dBm} = \frac{7.08}{2.818 \times 10^{-8} \text{ W} \left( \frac{\text{J}}{\text{Sec}} \right)} = \frac{\# \text{ Photons}}{\text{Sec}}$$

$$h\nu = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \text{ J}\cdot\text{s} \cdot 3 \times 10^8 \text{ m/s}}{1550 \times 10^{-9} \text{ m}} = 1.29 \times 10^{-19} \text{ J}$$

$$= \frac{5.5}{2.2 \times 10^{11} \text{ Photons/Sec}} = \frac{222}{2.488 \times 10^9 \text{ b/s}} = 88 \text{ Photons/Sec}$$

Done ✓